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Polygenic Variations and Character Association Study of Tomato (*Solanum lycopersicon* L.) Genotypes for Yield and Quality Attributes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted in the Vegetable Farm of Bihar Agricultural University in Rabi Season with the objective to study the genetic variability and character association for yield and quality attributes in thirty tomato genotypes. The experiment was laid out in randomized block design with three replications. The results indicated significant differences amongst the genotypes for all the characters studied. Yield per plant showed the highest coefficient of variations (56.41 %, 58.93%) at both genotypic and phenotypic level. High genotypic and phenotypic coefficient of variation was also noted for average fruit weight (48.33%, 48.98%) and number of fruits/plant (35.14%, 33.55%). Traits like average fruit weight (97.4%, 41.85), number of fruits per plant (91.2%, 25.90), and plant height (95.8%, 69.38) exhibited high heritability coupled with high genetic advance. Genetic advance as percentage of mean ranged from 11.81-111.22% for different

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characters. The highest genetic advance as percentage of mean (111.2%) was recorded for yield per plant. Fruit yield per plant expressed highly significant and positive genotypic and phenotypic correlations with average fruit weight (0.697, 0.694), equatorial diameter (0.637, 0.596) and polar diameter (0.488, 0.454). The genotypes, Hisar Lalit, Pusa Ruby, Arka Alok, Pant T-7 and Pusa Rohini which have been found to be promising with respect to fruit weight and yield per plant may further be exploited to create new genetic variations by random mutation, somaclonal variation and modern molecular techniques for studying disease resistance, post-harvest and processing qualities.

Keywords: Genetic variability; breeding programme; variability; genotypes.

ABBREVIATIONS

G : Gram
kg : Kilogram
q : Quintal
cm : Centimeter
m : Meter
ha : Hectare
% : Per cent
TSS : Total soluble solids

1. INTRODUCTION

Tomato (*Solanum lycopersicon* L.) is an important member of solanaceae family. It is the most important warm season fruit vegetable grown throughout the world and is one of the most popular and widely grown vegetable. Tomato is generally consumed as salad, cooked or as processed food. Tomatoes are important source of lycopene (an antioxidant), ascorbic acid fiber, carotenoids, potassium, total antioxidants, and phenolic compounds and valued for their colour and flavor [1,2]. Tomato is known as protective food because of its special nutritive value and also for its widespread production [3]. Greater the diversity in the material more greater are the chances for selection to get desired types. The estimates of different genetic parameters and the association of different characters are important for better understanding of the nature and the magnitude of genetic variability present in the breeding material. India is the richest country for diverse genotypes of tomato. Identification of superior genotypes among the existing germplasm becomes imperative for future breeding programme and for promoting production per unit area. Over the last centuries, plant breeders have developed various tomato cultivars through domestication and breeding, releasing modern tomato varieties and hybrids of different shapes, colors, and sizes [4,5]. Systematic study and evaluation of germplasm is of great importance for current and future agronomic and genetic improvement of the crop [6]. The development of an effective improvement programme in turn depends upon the existence of variability and knowledge of genotypic and phenotypic correlation of yield and quality attributes in the genotypes. Such information gives the cause and effect relationship between different pairs of variables [7]. Keeping these facts in view, an experiment was conducted with the objective to study the genetic variability and Character Association Study of Tomato (*Solanum lycopersicon* L.) Genotypes for Yield and Quality Attributes.

2. MATERIALS AND METHODS

The present experiment was conducted in the Vegetable Farm of Bihar Agricultural University, Sabour in Rabi Season. Sabour is geographically situated between 25˚ 15'40''N latitude to 87˚2'42''E longitude at 46 m above mean sea level in the heart of the vast Indo-Gangetic plains of north eastern India. The total rainfall received during the crop period was 108.4 mm. The maximum temperature ranged from 20.0˚C -34.6˚C during the plant growth and development phase.

The experimental material consisted of thirty genotypes of tomatoes. These genotypes were selected out of the germplasm collection maintained in the Department of Horticulture (Vegetable and Floriculture) at the Bihar Agricultural College, Sabour. The experiment was laid out in randomized block design having three replications. The study was performed on characters namely plant height, number of primary branches per plant, number of fruits per plant, days to first flowering, days to 50% flowering, days to first harvesting, average fruit weight (g), equatorial diameter (cm),polar diameter (cm),number of picking, yield per plant (kg),fruit yield (q/ha),stigma nature (inserted/exerted),fruit shape, fruit colour, number of locules per fruit, pericarp thickness (cm) and TSS (^{0}Brix). The data were analyzed statistically according to the method outlined by Fisher [8]. Phenotypic and genotypic coefficient of variation was calculated by method as suggested by Comstock and Robinson [9]. Heritability (h^2) in broad sense and genetic advance was calculated as per formula suggested by Burton and Devane [10]. Phenotypic and genotypic correlation coefficients were calculated as per formula suggested by Al-Jibouri et al. [11].

3. RESULTS AND DISCUSSION

The results indicated significant differences amongst the genotypes for all the characters studied (Table-1). Significant differences amongst the genotypes for all the characters studied in this investigation can have appreciable scope of improvement in tomato. The genetic variability estimates for different traits are genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance and genetic advance as per cent of mean which have been depicted in Table-2. The coefficient of genotypic and phenotypic variability is a useful tool for determining the degree of variability for a particular character. In general, phenotypic coefficient of variation was found to be higher than its corresponding genotypic coefficient of variations. The higher PCV values in comparison to the GCV values suggested that there was some influence of environment on all the traits under study which was previously reported by Dar and Sharma [12]. Yield per plant showed the highest coefficient of variations (56.41 %, 58.93%) at both genotypic and phenotypic level. High genotypic and phenotypic coefficient of variation was also noted for average fruit weight (48.33%, 48.98%) and number of fruits/plant (35.14%, 33.55%). Similar observations were made by Bukseth et al. [7] and Kaushik et al. [13]. Genotypic and phenotypic coefficients of variation were also high for plant height and number of locules per fruit. Similar observations were also made by Ahirwar et al. [14], Kumar et al. [15] and Pandey et al. [16]. This indicated the possibility ofobtaining higher selection response in respect of these traits.The highest estimate of heritability (98.18%) was observed for number of locules per fruit closely followed by average fruit weight (97.4%), pericarp thickness (96.3%), plant height (95.8%), TSS (91.7%), yield per plant (91.6%), number of fruits per plant (91.2%), polar diameter (85.3%), equatorial diameter (85.2%), number of primary branches per plant (79.9%), days to first harvesting (79.3%), days to 50% flowering (64.9%), number of picking (62.5%).Similar findings were reported by Agarwal et al. [17], Bhandari et al. [18], Rai et al. [19] and Kumar et al. [20].These characters are, therefore, governed by additive gene effects. It can also be concluded that selection on the basis of these characters will be more useful for the improvement of this crop towards attaining higher yield. However, days to first flowering, days to first harvesting and TSS exhibited moderate genetic heritability along with moderate genetic advance, indicating that all these characters are controlled by both additive and non-additive of genes. The data with respect to genetic advance among the different characters under investigation indicated that the high genetic advance for plant height (69.38) followed by average fruit weight (41.85),number of fruit per plant (25.90) whereas days to first harvesting (19.91) had moderate genetic advance while days to 50% flowering (8.35), days to first flowering (7.88), number of primary branches per plant (2.75), number of locule per fruit(2.53), number of picking (1.95), yield kg per plant (1.90), equatorial diameter (1.73), polar diameter(1.61), TSS (1.26) and pericarp thickness (0.17) showed lower genetic advance. Genetic advance as percentage of mean ranged from 11.81-111.22% for different characters. The highest genetic advance as percentage of mean (111.2%) was obtained for yield per plant. Similar results were noticed by Shashikanth et al. [21], Ghosh et al. (2010), Al-Yash et al. [22] and Saleem et al. [23].

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. The data on both genotypic and phenotypic correlation coefficient (Table 3a and Table 3b) in the present experiment revealed that fruit yield per plant expressed highly significant and positive correlation with average fruit weight (0.697, 0.694), equatorial diameter (0.637, 0.596) and polar diameter(0.488, 0.454). Thus while making selection for high yield, the characters like average fruit weight, equatorial diameter and polar diameter must be taken into account. Genotypic correlation coefficient in the present

Table 1. Analysis of variance (ANOVA) for 14 quantitative characters in tomato

S.N.	Characters	Replication	Treatment	Error
		df=2	df=29	df=58
1.	Days to first flowering	745.81	156.04**	29.04
2.	Days to 50% flowering	473.2	159.48**	32.42
3.	Days to first harvesting	811.23	544.06**	58.38
4.	Plant height (cm)	404.96	3602.93**	51.58
5.	No. of primary branches/plant	0.33	7.25**	0.56
6.	No. of fruit/plant	51.46	553.78**	11.64
7.	Average fruit wt.(g)	21.64	1283.39**	11.5
8.	Equatorial diameter (cm)	0.43	2.63**	0.14
9.	Polar diameter (cm)	0.47	2.63**	0.12
10.	No. of picking	0.14	10.58**	0.98
11.	No. of locules/fruit	0.02	5.21**	0.03
12.	Pericarp thickness (mm)	0	0.02**	0.003
13.	TSS (^{0}Brix)	0.13	1.26**	0.04
14.	Yield/plant (kg)	0.16	2.70**	0.04

*** = Significant @1% probability level*

Table 2. Estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) and heritability, genetic advance and genetic gain as percent of mean

S.N.	Characters	Range	Mean	Genotypic variance	Phenotypic variance	GCV%	PCV%	Heritability (%)	Genetic advance	Genetic advance as % age of mean
1.	Days to first flowering	32.67-60.67	53.340	24.77	41.89	9.33	12.13	59.1	7.88	14.78
2.	Days to 50% flowering	50-78	70.730	25.31	39.00	7.11	8.83	64.9	8.35	11.81
3.	Days to first harvesting	103.33-162.33	143.400	117.89	148.71	7.57	8.50	79.3	19.91	13.89
4.	Plant height(cm)	66.23 - 183.43	112.423	1183.78	1235.36	30.60	31.26	95.8	69.38	61.71
5.	No.of primary branches/plant	4.53 - 11.87	6.767	2.23	2.79	22.06	24.69	79.9	2.75	40.62
6.	No.of fruit/plant	16.83 - 67.53	39.247	173.40	190.20	33.55	35.14	91.2	25.90	66.00
7.	Average fruit wt.(g)	9.63 - 84.64	42.604	423.96	435.46	48.33	48.98	97.4	41.85	98.24
8.	Equatorial diameter (cm)	2.15 - 5.78	4.001	0.83	0.97	22.74	24.64	85.2	1.73	43.22
9.	Polar diameter (cm)	2.17 - 5.57	3.849	0.72	0.84	22.04	23.86	85.3	1.61	41.94
10.	No. of picking	4.67-9.67	8.067	1.4337	2.29	14.84	18.76	62.5	1.95	24.19
11.	No. of locules/fruit	2.00-6.57	4.439	1.5458	1.57	28.01	28.27	98.1	2.53	57.17
12.	Pericarp thickness (mm.)	0.23 - 0.62	0.406	0.01	0.01	20.85	21.25	96.3	0.17	42.16
13.	TSS(^{0}Brix)	2.62 - 5.72	4.251	0.41	0.44	15.02	15.68	91.7	1.26	29.64
14.	Yield/pt.(kg)	0.36 - 4.02	1.710	0.93	1.02	56.41	58.93	91.6	1.90	111.22

Table 3(a). Estimation of phenotypic correlation coefficient for different quantitative characters in tomato

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	Y
X_1	1.000	0.517**	0.529**	-0.200	-0.182	-0.175	0.083	0.109	0.266	-0.110	0.130	0.201	-0.214	-0.044
X_2		1.000	0.487**	-0.208	-0.174	-0.169	0.072	0.091	0.254	-0.095	0.122	0.183	-0.217	-0.061
X_3			1.000	-0.288	-0.234	-0.176	0.179	0.164	0.306	-0.162	0.141	0.287	-0.136	-0.013
X_4				1.000	0.554**	0.257	-0.276	-0.258	-0.408	0.156	-0.269	-0.439**	0.424**	-0.144
X_5					1.000	0.188	-0.263	-0.291	-0.461**	0.178	0.021	-0.516**	0.486**	-0.168
X_6						1.000	-0.354	-0.333	-0.321	0.201	-0.292	-0.419*	0.297	0.353
X_7							1.000	0.889**	0.658**	-0.086	0.223	0.556**	-0.130	0.694**
X_8								1.000	0.611**	-0.100	0.273	0.509**	-0.236	0.596**
X_9									1.000	-0.121	-0.068	0.663**	-0.248	0.454**
X_{10}										1.000	0.076	-0.202	0.107	0.038
X_{11}											1.000	-0.047	-0.100	0.016
X_{12}												1.000	-0.276	0.234
X_{13}													1.000	0.089

Table 3(b). Estimation of Genotypic correlation coefficient for different quantitative characters in tomato

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	Y
X_1	1.000	0.612**	0.642**	-0.261	-0.221	-0.206	0.126	0.144	0.313	-0.212	0.181	0.282	-0.298	-0.047
X_2		1.000	0.646**	-0.294	-0.232	-0.198	0.107	0.129	0.303	-0.182	0.178	0.266	-0.299	-0.049
X_3			1.000	-0.334	-0.300	-0.210	0.216	0.209	0.351	-0.241	0.169	0.343	-0.190	-0.021
X_4				1.000	0.626**	0.274	-0.295	-0.322	-0.475**	0.150	-0.274	-0.454**	0.451**	-0.150
X_5					1.000	0.206	-0.300	-0.321	-0.559**	0.237	0.023	-0.613**	0.552**	-0.161
X_6						1.000	-0.366*	-0.341	-0.349	0.216	-0.309	-0.451*	0.314	0.362
X_7							1.000	0.949**	0.708**	-0.099	0.229	0.568**	-0.145	0.697**
X_8								1.000	0.604**	-0.151	0.307	0.555**	-0.263	0.637**
X_9									1.000	-0.164	-0.068	0.720**	-0.257	0.488**
X_{10}										1.000	0.084	-0.235	0.121	0.070
X_{11}											1.000	-0.051	-0.105	0.016
X_{12}												1.000	-0.298	0.252
X_{13}													1.000	0.094

X_1 = Days to first flowering
X_2 = Days to 50 %flowering
X_3 = Days to first harvesting
X_4 = Plant height (cm)
X_5 = No.of primary branches/plant
X_6 = No.of fruit/plant
X_7 = Average fruit weight (g)
X_8 = Equatorial diameter (cm)
X_9 = Polar diameter (cm)
X_{10}=No.of picking
X_{11}=No.of locule/fruit
X_{12}=Pericarp thickness (mm)
X_{13}=TSS

Y =Yield/pt(kg) = Significant @5% level of significance ** = Significant @1% level of significance* experiment was found to be very slightly higher than their corresponding phenotypic correlation coefficient for most of the characterswhich suggested that there was inherent relationship between the traits under study, and environment had not played much role in reducing their actual association. Similar findings in tomato were also reported by Sharma and Verma [24], Bhushana et al. [25], Tiwari [26], Harer et al. [27], Singh et al. [28], and Prashanth et al. [29].

4. CONCLUSION

Thus, it concluded that for the selection of superior may be genotypes in tomatoes, average fruit weight, number of fruit per plant, number of locules per fruit, polar diameter, plant height, number of fruits per plant, and pericarp thickness must be subjected to selection pressure for effective improvement in this crop. For improvement of traits like average fruit weight, number of fruits per plant, and plant height which exhibited high heritability coupled with high genetic advance, selection in early generations would be effective. The genotypes Hisar Lalit, Pusa Ruby, Arka Alok, Pant T-7, and Pusa Rohini were found to be promising with respect to plant height, number of fruits per plant, fruit weight and yield/plant.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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